# Executive Summary

## Introduction

Limited supplies of fresh water are a concern worldwide and especially in South Africa where annual rainfall falls well below the world average. Reuse of greywater offers one means of relieving pressure on fresh water supplies. It is established practice in a significant minority of households, especially in low income settlements where water is difficult to obtain and families are under financial pressure to minimise use of all resources. Use of greywater specifically for irrigation is practised to a lesser extent than for other household uses, but does occur in middle and higher income suburbs in times of drought, and in low income areas to supplement water supplies for food production. Active promotion of greywater use for irrigation in gardens and small-scale agriculture has the potential not only to maximise use of limited water supplies, but also to improve food security in low income settlements. However, before this can be promoted through government structures and local authorities, the legal status of greywater use for irrigation needs to be clarified and guidance needs to be formulated for users so that small-scale irrigation use of greywater is performed in a way that is safe for humans, plants and the environment. The development of such guidance is the purpose of this project.

## Aim and objectives

### *Aim*

To develop guidelines for the sustainable use of greywater in small-scale agriculture and gardens in rural villages, peri-urban and urban areas of South Africa.

### *Objectives*

1. Identify and describe the areas where greywater use is an established practice.
2. Refine knowledge on the *status quo* of greywater use (where, who, why, how, quantities and qualities) and needs of actual and potential users of greywater.
3. Review the social and anthropological acceptability of greywater use.
4. Review the current institutional and legal framework for use of greywater in consultation with relevant government departments.
5. Document the available knowledge (including the previous four objectives, other WRC projects and South African and international experience) and other considerations in a Technical Report that records the proposed rationale and associated limits for South African conditions as reflected in the Draft Generic Guidelines.
6. Draft Generic Guidelines for sustainable use of greywater in small-scale agriculture and gardens based on the rationale provided in the Technical Report.
7. Workshop the draft generic guidelines with Water Service Authorities (WSAs), Water Service Providers (WSPs), users and other interested and affected parties (IAPs) to test the feasibility and acceptability thereof.
8. Identify the most important gaps in knowledge that should be addressed to refine the draft guidelines.
9. Conduct a number of case studies designed to fill these gaps in knowledge.
10. Test the draft guidelines against current practice.
11. Update the Technical Report to record the rationale and associated limits for the final set of guidelines.
12. Consult with regulating authorities and potential users of the guidelines about the acceptability of the proposed rationale and associated limits for the guidelines.
13. Identify, document and prioritise the remaining crucial issues relating to greywater use that would need to be investigated in follow-on research.

14. Prepare a final set of final user friendly guidelines for different target groups (*e.g.* sewered *vs.* unsewered; urban *vs.* rural; inland *vs.* coastal, *etc*.) for current and potential use of greywater in small-scale agriculture and gardens in rural villages, peri-urban and urban areas of South Africa.

# Approach adopted to address project aim and objectives

The development of a Guidance Report for greywater irrigation and a supporting Technical Report followed the process outlined below:

- Survey of national and international literature (peer-reviewed literature, legislation and guidelines, technical reports and 'grey' literature) to identify existing knowledge and key issues.
- Identification of gaps in knowledge, and initiation of case studies to address these.
- Exploratory workshop with policy-makers and questionnaire surveys of local authorities and of water users in sewered settlements (questionnaire surveys of unsewered settlements were available from previous studies).
- Identification of greywater constituents of interest from existing studies of greywater quality in South Africa.
- Development of preliminary draft greywater quality guidelines for all identified constituents.
- Peer review to reduce number of constituents, refine the draft quality guideline and set the framework for other issues to be covered in the guideline.
- Compilation of complete draft guidelines, containing sections on
  - Managing risks and uncertainty in greywater irrigation,
  - Greywater quality,
  - Greywater quality mitigation, and
  - Greywater quantity.
- Submission of complete draft guideline to peer review.
- Capacity building workshops at municipality level, and consultation with national policy-makers.
- Incorporation of outcomes of the case studies, peer review and consultation into the Guidance Report and the Technical Report.
- Formulation of implementation and research recommendations on the basis of all work conducted, and inclusion thereof in the Technical Report.

# Summary of outcomes

## *Literature review and case studies*

Supporting literature was reviewed in the Technical Report. It was noticed that information from South Africa was particularly sparse. Six case studies were conducted to address knowledge gaps identified in the literature and to support development of the Guidance Report. These were:

- Case Study 1: Plant growth, soil characteristics and microbiological quality of vegetable crops irrigated with domestic greywater in eThekwini Municipality
- Case Study 2: Consultative process supporting development of the Guidance Report
- Case Study 3: Identifying greywater quality constituents for inclusion in the Guidance Report
- Case Study 4: Greywater treatment
- Case Study 5: Impact of cleaning products on greywater quality
- Case Study 6: Estimating greywater volumes for irrigation.

## *Outcomes of literature review and case studies*

The most salient points emerging from the literature review and the case studies were collated, as follows.

*Greywater quality and quantity*

- Kitchen greywater should not be used for irrigation unless it undergoes some form of treatment first.
- It is preferable to use only the rinse water of the laundry greywater fraction for irrigation.
- The greywater constituents identified as being of the greatest relevance to greywater irrigation in South Africa are:
  - Electrical conductivity (EC)
  - Sodium adsorption ratio (SAR)
  - *Escherichia coli*
  - pH
  - Boron
  - Chemical oxygen demand (COD)
  - Oil and grease
  - Suspended solids
  - Total nitrogen
  - Total phosphorus.
- Estimation of greywater quantities for irrigation should be based on the water needs of plants and not on the disposal of greywater.
- Using relatively simplistic methods, it is possible to provide users with an approximate guide to the volumes of greywater that can be applied. While this does not take into account the best that science can offer in terms of irrigation water planning, it takes cognisance of the need for guidance to be simple enough for relatively unsophisticated users to apply.

*Health implications*

- Sub-surface irrigation provides the best protection from microbial health risks; it can be implemented simply and should be encouraged.
- A multi-barrier approach to limiting human exposure, as advocated by WHO (2006), can reduce risks from even below-ground vegetables to within commonly recognised acceptable limits.
- Personal hygiene is an important exposure barrier in the use of greywater for irrigation.
- Cognisance must be taken of the vulnerability of HIV-positive persons to exposure to potential pathogens.
- Greywater has the potential to improve nutrient intake from home-grown food crops.

*Environmental water quality implications*

- Greywater must not be allowed to enter surface water bodies.
- Greywater must not be allowed to pond on the surface.
- While the impact of small-scale greywater irrigation on groundwater quality is likely to be minimal, groundwater must be considered when planning greywater irrigation implementations.

*Implications for plant growth and yield*

- In general, irrigation with mixed domestic greywater improves both growth and yield of crops relative to tap water, although yield appears to be boosted less than growth. It is unclear whether this effect extends to all types of greywater.

The effect varies among crops.

- Use of plants tolerant to certain greywater constituents, *e.g.* sodium or boron, can maximise the use of greywater for irrigation.
- Greywater users need to observe their plants for signs of stress and modify their greywater irrigation regime accordingly.

*Implications for soil properties*

- Sodium from detergents poses the greatest risk to soil properties, particularly in terms of soil salinity and soil sodicity.
- Soil should be leached to minimise the accumulation of salts.
- Steps should be taken to minimise the development of sodic soil conditions, *e.g.* addition of mulch (organic matter) or gypsum to soil.

*Greywater treatment*

- Greywater treatment systems should be sufficiently simple and robust to function effectively in rural and peri-urban settlements, preferably without power or piped water and with minimal technical expertise required for maintenance.
- Greywater treatment systems should use the simplest and most cost-effective technology required to meet the water quality objectives.
- Greywater treatment systems should be thoroughly tested and proven before being implemented in practice, to avoid user fatigue caused by system failure and on-going changes.
- Wherever possible, treatment systems that have been previously proven to work in South Africa should be considered before introducing new technologies which have yet to be proven under local conditions.

*Considerations for implementation of greywater irrigation*

Legal issues

- The legal status of greywater use for small-scale irrigation needs to be clarified.

Social issues

- Sewered settlements seem broadly similar in terms of greywater generation characteristics, while unsewered settlements must be evaluated on a case-bycase basis.
- Informal settlements often lack a sense of community and this hampers the development of initiatives seen to be for the greater good or even individual improvement. Greywater irrigation implementations in such environments cannot succeed unless a sense of community can first be fostered.
- In informal settlements, the quality of greywater is generally extremely poor. For greywater to be of a quality fit for irrigation use, greywater needs to be separated from other waste streams at source and the number of uses to which it is put need to be limited. This is contingent on provision of adequate water supplied otherwise users are driven by logistical and economic factors to maximise the use to which water is put before disposal. It is also heavily dependent on the provision of adequate sanitation and solid waste management.
- Commitment of users and managers of greywater irrigation implementations is essential if these are to succeed.

Education

- Local authorities urgently require capacity building in knowledge of greywater issues in general, and of the potential of greywater use for irrigation in particular.

- Potential irrigation users of greywater need to be involved in the planning and implementation of any greywater irrigation implementation, and must be educated on the risks, benefits and proper handling of greywater, of irrigated land and of greywater-irrigated crops.
- Although residents of unsewered and sewered settlements expressed reservations about the use of greywater for irrigation, there is already a culture of using greywater several times before disposal. This could be used as a foundation to promote use of greywater for irrigation.

Greywater use in new developments

- Probably the greatest potential for greywater use for small-scale irrigation is by including it in the planning of new communities or alterations to existing communities. However, it is important to ensure that the greywater technologies introduced have been proven to be sound; that designs are implemented correctly and that housing management and users are committed to using the facilities properly. Failure in any of these areas has been shown to lead to failure of greywater use projects.

## *Approach adopted for development of the Guidance Report for irrigation use of greywater*

Central concepts identified from the literature review and case studies, and deliberations of the project team and the Reference Group, together determined the underlying principles and the structure of the Guidance Report.

*Underlying principles*

The intended users of the Guidance Report were identified as:

- Municipalities or NGOs who wish to initiate greywater irrigation implementations or wish to support water users in developing and monitoring greywater irrigation implementations.
- Informed members of the public who wish to plan for irrigation use of greywater on their properties or in their settlements, and need guidance in doing so.

The focus of the Guidance Report was defined as:

- Minimisation of risks of *illness* in handlers of greywater and greywaterirrigated produce, or consumers of greywater-irrigated produce.
- Minimisation of risks of *reduction in growth or yield* of plants/crops irrigated with greywater.
- Minimisation of risks of environmental degradation, especially reduction in the *ability of soil irrigated with greywater to support plant growth*. In addition, the Guidance Report was developed within the following boundary conditions:
- Irrigation use is interpreted as the *beneficial use of greywater to support plant growth within the boundaries of the irrigated property only*. It is important to note that movement of greywater beyond the boundaries of the property is explicitly *excluded*, since this would amount to uncontrolled disposal of greywater to the environment and all the disadvantages and risks associated with that.
- The guidance provided is intended to address irrigation use of greywater only, not to provide a general solution for disposal of greywater. Thus the focus is not on maximising the volume of greywater which can be applied to land, but on minimising risks and on maximising benefits associated *specifically with irrigation use of greywater*.
- The guidance provided is intended to be used within the context of existing

knowledge and best practice relating to irrigation, *e.g.* selection of plants, installation and maintenance of irrigation equipment, and adaptation of irrigation schedules to local agroclimatic conditions. The guidelines focus not on providing a catch-all manual for small-scale irrigation implementations, but on *managing the additional risks and challenges* arising out of the use of greywater in such implementations.

*Structure of Guidance Report*

The structure decided upon for the Guidance Report is as follows:

What is greywater?
Why use greywater for irrigation?
Concerns about the use of greywater for irrigation
Health considerations
Plant growth and yield
Ability of soil to support plant growth
Purpose of the Guidance Report
Intended users of the Guidance Report
Focus of the Guidance Report
Major sources used
Legislative context of greywater use for irrigation
Special considerations
Guidance for greywater use in small-scale irrigation in South Africa
Guide to managing risks and uncertainty
Greywater quality: Guide to greywater constituents
Greywater quality: Mitigation of greywater quality
Greywater quantity: Guide to irrigation volumes

The core of the Guidance Report is provided by the section “Guidance for Greywater Use in Small-Scale Irrigation in South Africa”. In the sub-section on “Managing Risks and Uncertainty in Greywater Irrigation”, three categories of greywater use are identified, based on the extent of characterisation of greywater and, by implication, on compliance with quality limits. Use restrictions are identified for each category. The most stringent restrictions apply to greywater used without characterisation. Minimum analysis – comprising pH, electrical conductivity, sodium adsorption ratio and *E. coli* –, and compliance with quality limits on these, are associated with less stringent restrictions. The least restrictions are associated with use of greywater undergoing full analysis (minimum analysis plus boron, chemical oxygen demand, oil and grease, suspended solids, total inorganic nitrogen and total phosphorus). The quality limits in each category are specified in the sub-section on “Greywater Quality: Guide to Greywater Constituents”. The section on “Greywater Quality: Mitigation of Greywater Quality” provides means of adjusting to or improving on greywater quality. Two approaches are considered: agricultural practices to mitigate the effect of, predominantly, chemical constituents such as sodium; and treatment to improve, predominantly, the organic and microbiological quality of greywater. The last subsection,

“Greywater Quantity: Guide to Irrigation Volumes” guides users in selecting the volume of greywater to be applied and in adjusting this for site-specific conditions.

## Major recommendations

Recommendations for the dissemination of the outputs of the project, implementation of the Guidance Report and further research to address remaining knowledge gaps were formulated, again based on the literature review and the outcomes of the case

studies.

### *Implementation: Dissemination of Guidance Report*

- All local authorities, as well as Water Boards, should be informed directly of the imminent release of the Guidance Report, once an approximate release date is known.
- The Water Institute of Southern Africa (WISA) should be used to publicise the release of the Guidance Report to its members.
- Consideration should be given to establishing a Greywater web page on the WRC web site.

### *Implementation: Capacity building at Local Authority level*

- A short educational pamphlet on greywater and greywater irrigation, aimed specifically at local authorities, should be developed and distributed.

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- Attendees at a capacity building workshop, held in January 2010 to introduce local authorities to the Guidance Report, requested that the workshop be repeated annually. They requested addition of a practical component during which hands-on experience could be obtained of successful interventions.
- Another request made by attendees at the capacity building workshop referred to above was a forum in which questions could be asked and experiences exchanged on an ongoing basis.

### *Implementation: Education of greywater users*

- Potential greywater users need to be involved in planned greywater implementations from the planning stages, informing them of the benefits and risks of greywater use for irrigation, allowing them to express their views and concerns, and providing a mechanism for them to be involved in decisionmaking.
- Potential irrigation users of greywater need information to practice greywater irrigation in a safe and sustainable manner. Although this information is provided in the Guidance Report, it would be helpful to provide users with quick reference sheets to support the more comprehensive Document. This could take the use of one-page information sheets.
- Once a greywater implementation has been planned and initiated, greywater users need ongoing monitoring and support. This should be tailored to meet the different information and support needs of low income rural and peri-urban settlements and middle to higher income urban settlements.

### *Legislation: Recognition of greywater and beneficial greywater use in water and waste legislation*

- Current legislation pertaining to disposal and use of water and waste falls short in that a definition of greywater as a separate wastewater stream is lacking. Clarity is needed for the future by explicit definition of greywater and the beneficial uses to which it may be put.

### *Research: Remaining knowledge gaps*

- Suitable indicator micro-organisms for health protection.
- Identification of the greywater quality constituents which most contribute to deterioration in plant growth, crop yield, crop quality and soil characteristics.
- Maximising fertiliser potential of greywater.
- Trialling of ‘green’ cleaning products to test whether the greywater generated with these does indeed preserve plants, crops and soil relative to greywater generated with conventional cleaning products.

- Cost-effective proven on-site treatment processes that are sufficiently robust for implementation in low income communities.
- Role of different soil types on interaction with greywater.
- The pollution potential of managed greywater irrigation.

In addition, review of the Guidance Report is recommended in one to two years, with updates to be made based on experience in practice.